Institute for Manufacturing

Centre for Technology Management

The Cambridge High Tech Cluster: resilience and response to cyclical trends

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No: 2009/01, January 2009

UNIVERSITY OF CAMBRIDGE

Centre for Technology Management Working Paper Series

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ISBN 978-1-902546-70-4

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Report for IPGC

(EPSRC grant IPGC RG44/02 NMZM/ 072)

Summary

This paper explores trends shown by technology based companies in the Cambridge area over the cycles of the past two decades. Influences from the macro-economy include the impact of the information revolution on the area, the recession of the early 1990s and the technology crash of 2000. The expansion of the cluster of Cambridge tech firms over time reflects the extent to which firm entries have exceeded exits since the 1960s and the high survival rates of new firms. There has been sector-specific volatility in the current decade, pre-figuring economic difficulties since evident elsewhere. In order to reveal the dynamics behind trends at the cluster level, data are examined by sector, size and cohort. This shows that the decline in firm numbers between 2002 and 2006 reflects the founding of large numbers of short-lived IT software firms during the technology boom.

Branches of corporations headquartered elsewhere have increasingly been attracted to the area but the larger tech based businesses in the Cambridge area are found to be those long-standing to Cambridge. Branch firms were more prone to closure and relocation than the larger indigenous firms with their accumulated local competence. Biotech and R&D experienced steady growth through the 1990s and 2000s with an increase in firm and job numbers. The biotechnology sector contracted along with the recent reduction in venture capital but the R&D sector continued to grow.

Cambridge technology firms have been attractive targets for acquisition by corporations seeking to improve their innovation performance by buying promising technology. The number of acquisitions rose during the boom years, particularly in Biotech and IT, with associated cutbacks in employment in acquired units. The boom in venture capital investment and the incidence of acquisition during the boom period may be related. VCs seek early exit from their investments and acquisition rates fell along with the fall in local venture capital funding.

After 2004, the fall in the number of tech start-ups (as compared with county VAT registrations for all new firms) and increasing numbers of exits, indicate that Cambridge tech-based firms were experiencing pressures specific to high tech. Long term effects of lower firm entries will depend on survival rates and the growth of surviving firms. During the recession of the early 1990s, a smaller cohort of tech start-ups achieved higher survival rates than those started in boom years. The number of new firms active in emerging technology sectors points to continuing innovation and diversity among firms in the Cambridge technology cluster despite a contraction in numbers of start-ups which anticipated the economic downturn. In the current financial situation, knowledge based firms engaged in technological and creative activity are more important than ever as providers of exports and of the skills of the future.

The Cambridge High Tech Cluster:
resilience and response to cyclical trends

Introduction

Innovative economic activity is stimulated by scientific and engineering research only under certain conditions. R&D must give rise to new goods and services either from established or entrepreneurial ventures meeting specialist demand in the international economy (OECD 2000; Mowery and Rosenberg 1998; Best 2000). Cambridge tech-based firms have been hailed as demonstrating that new applications of knowledge can generate important innovations in local clusters of innovative firms (Minshall 2008; Library House 2006). In economic history, emerging and early diffusing tech firms (high tech clusters) followed broad cyclical patterns, but with amplified growth during economic upturns and sharp sector-specific downturns. With this in mind we explore trends in firm and job numbers in technology based firms in the Cambridge area in relation to the recession of the early 1990s, the expansion of the late 1990s and the economic volatility of the current decade. We find that Cambridge tech firms were relatively resilient to cyclical pressures during the 1980s and 1990s but that there was sector-specific volatility in the current decade, pre-figuring economic difficulties that have since become evident elsewhere in the economy.

Why are firms that base their activities on emerging and newly diffusing technologies (high tech firms) prone to economic cycles? Sector-specific booms and business cycles have been associated with emerging technologies since the industrial revolution. As pioneering technologies come to win customers and eventually bring in returns to early investors, they attract further investment. With diffusion of the technology, above average profits are eroded with the onset of competition. Inflated expectations subside, often marked by a collapse of investment support. Booms and slumps are not merely a response to macro conditions (Atella, et al.2008). They have also been set off by the emergence of major technologies since the early days of canal and railroad transport (Nairn 2002; Baines et al 2003*)*. Confidence was eventually restored when further sales and returns reassured investors and the technology continued to be diffused (Nairn 2000; Gartner 2006). Since new technologies tend to swarm (Schumpeter 1928), this syndrome may work its way through a swathe of related technologies, as occurred during the Internet boom and crash around the year 2000.

Cyclical influences have until recently been neglected in cluster studies. Cycles at the macro level do not map directly onto local trends in firm and job numbers (Audretsch and and Acs 1994). Economic cycles are tracked by such indicators as rates of GNP growth and changes in share prices, but the relationship between these factors and local trends is complex, because of the multiplicity of other influences to which young technology firms are subject. They are affected by factors which include local

infrastructure, local industry shifts, investment patterns and skill availability. Attempts to isolate and model the impact of such variables with limited data availability could result in spurious precision (Collard and Dellas 2007). Our aim is simply to examine recent trends in a well known high tech cluster, using a longitudinal business dataset, in order to identify discontinuities in the expansion and contraction of technology-based firms and jobs, against the background of cyclical influences

Overview of trends in technology based activity in the Cambridge Area

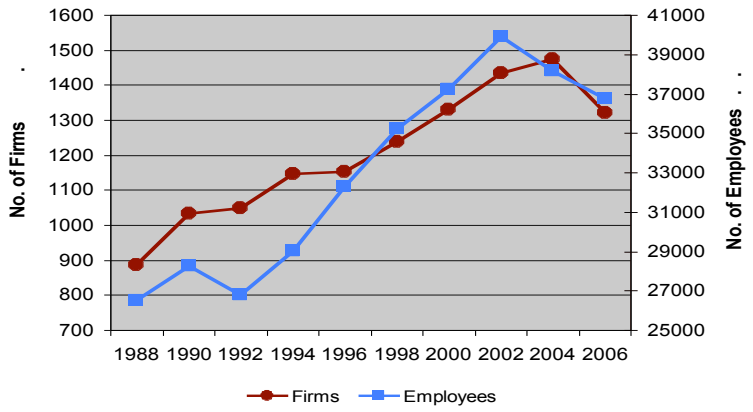
The expansion of high tech activity in Cambridge coincided with the information revolution. Earlier studies have shown that Cambridge was a pioneering centre of advanced computing power which was made available to private firms through time-sharing arrangements provided by the university's government-funded Atlas Computer (Garnsey and Cannon-Brookes 1992, Garnsey and Heffernan 2005). A number of IT enterprises were founded in the late 1970s and the 1980s, contributing to the rapid rise in numbers of tech based firms in the area over the latter decade. The location of the government CAD centre gave rise to enterprise in Computer Aided Design, resulting in the spin-out of a number of companies, including Cambridge Interactive Systems. These pioneering companies were acquired as CAD matured and the international CAD industry consolidated. Some of the acquired firms were relocated and closed. However knowledge developed by entrepreneurs and engineers active in CAD was applied to Geographic Information Systems (GIS) and other information technologies, with the founding of such firms as Smallworld and the recruitment of CAD engineers into many other local IT companies.

Long-lived spin-outs from the university engineering department, Cambridge Instruments and Pye, the radio and instruments company, were founded in the nineteenth century and the 1930s, respectively. Both experienced problems in making the transition from the electro-mechanical technologies to applying information technology throughout their systems and were subject to merger and acquisitions as their industries consolidated, with the loss of several thousand jobs in Cambridge in the early 1990s. Government assistance was available through Manufacturing Modernisation programmes in US (Best 1999) and subsidies to German engineering firms to encourage the transition to IT based systems. US and German companies became leading customers of the Cambridge CAD companies' pioneering CAD products like MEDUSA. In the UK, the Thatcher government was retreating from government assistance to industry. The local instruments sector did not fully recover from the closures and drastic downsizing of the larger instruments firms in Cambridge. However the downsized companies became a source of experienced managers for local firms founded in the area to exploit new information technologies.

The rise and fall in numbers in the recession of the early 1990s is reflected in our longitudinal dataset on technology based firms in Cambridgeshire (Figure 1).[1]

[1] The Appendix describes the database

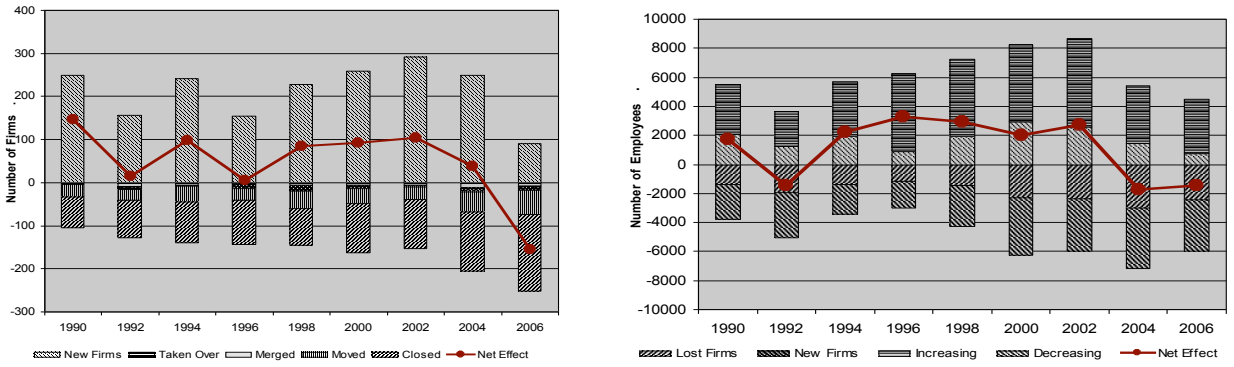
Figure 1 Total Number of High Tech Firms and Total High Tech Employment in Cambridgeshire 1988-2006



During the recession of 1990-1992, Cambridge high tech activity was more resilient than activities in many other places. Nationally, there was a reduction in GDP of 2.5% and company earnings declined by 25%. Unemployment rose from 6.9% in 1990 to 10.7% in 1993 (Office of National Statistics). The marked fall in jobs seen in figure 1 between 1990 and 1992 mainly took place in the few older, larger firms in the area. This was followed by a stabilisation in the number of firms. Entries of new firms soon resulted in expansion in numbers of tech based firms in the area, and employment had recovered by 1994, as small new firms provided jobs that made up the numbers depleted in earlier job losses in the larger instruments firms (Garnsey and Cannon Brookes 1992).

Analysis of entry and exit rates of firms in the area show a high rate of churn, with a hundred firms starting or closing in some years. This instability underlies the aggregate trends in figure one. From 1996 to 2002 the net effects of exit and entry of tech-based firms contributed to cumulative growth in numbers while the international technology boom was in strong upswing. Resilience was again in evidence during 2000 – 2002. There was only a slight decrease in numbers of tech firms and jobs in the Cambridge area during the technology crash of 2000, with its dramatic share price rise and fall on the New York technology stock market. In the wider UK economy a recovery after the fall in GDP of 2004 was fuelled by the boom in property prices. High levels of start up indicated by county VAT registrations after 2004 was not experienced by Cambridge high tech companies (figure 2.) Among Cambridge tech firms new start-ups fell after 2004 to below the rate of start-ups measured by VAT registration of all new firms in Cambridgeshire (GCP, 2007), indicating that tech based firms were not benefiting from the factors associated with the property boom that were fuelling non-tech start-ups in the county. This is congruent with a fall after 2004 in the number of university start-ups, predominantly technology firms, as reported by Cambridge University Research Services.

Figure 2 Entries and exits of high tech firms and employees in Cambridgeshire between 1988 and 2006

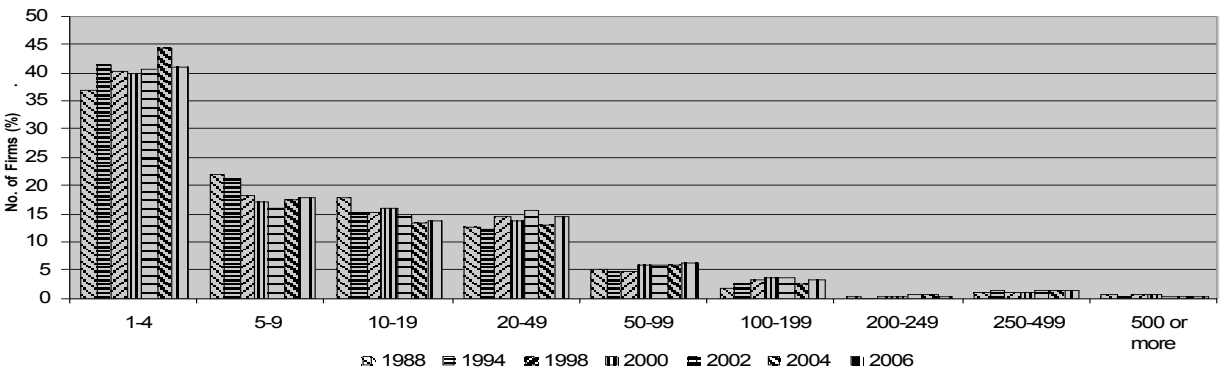


The contrast between VAT registrations among all start-ups in Cambridgeshire and the fall in tech start-ups in Cambridgeshire after 2004 suggests that tech start-ups may have been disproportionately affected by financial stringency during the housing boom.

Firms by Size Category

Disaggregating firms by more detailed categories reveals some of the factors underlying the totals. Changes in firms size measured by employment between 1988 and 2006 (*Figure 3)* point to the constituents of changes at the cluster level. The size distribution shown in figure 3 is a percentage of the total number of firms for that year.

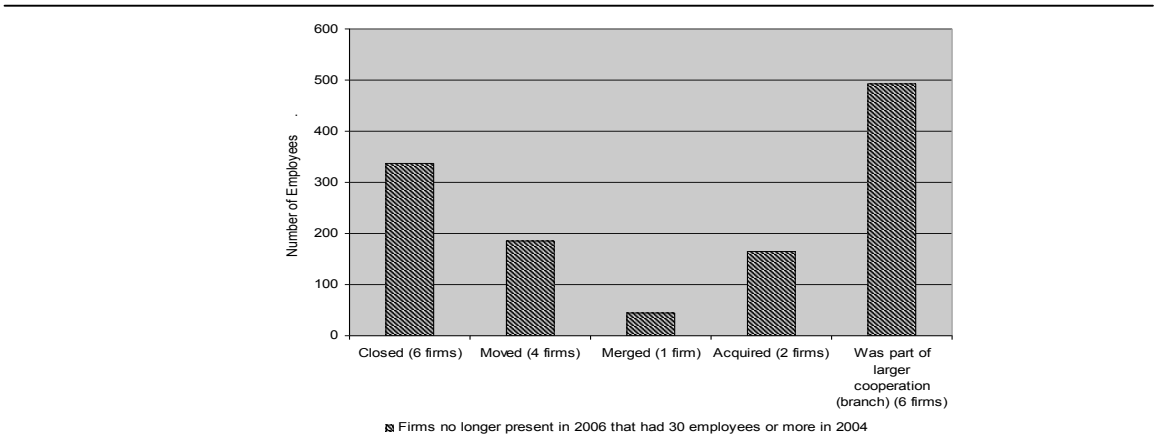
Figure 3 Size Distribution of Cambridgeshire tech firms by year, 1988 to 2006



Analysis of firms by employment size shows that the aggregate fall in firm numbers after 2004 seen in *Figure 1* reflects the fall in the smallest size category of 1- 4 employees (micro-firms), just as earlier expansion had been led by a boom in this category. In 2006 the percentage of firms in every size category other than micro (1- 4) was higher than in 2004.

It is often remarked that there are few large tech based businesses there are in the Cambridge area (e.g. Owen 2004), The size distribution of Cambridge tech firms is actually less skewed in the direction of small firms than is the case nationally, where the preponderance of small firms is even greater (Garnsey and Heffernan 2005). The shortage of established 'anchor' firms in the area is a matter of concern where these firms provide custom for other local firms and are better able to survive temporary downturns in their markets. However those establishments in the database most likely to cease trading in the area were implanted branch establishments which had the largest associated job loss on exit (figure 4), We explore this issue further below, in analysing changes in firm size. Larger firms founded in the area were more likely to remain in the area than were implants, even when the former experienced changes of ownership. Local branches set up in the area of firms headquartered elsewhere proved to be less well anchored than firms originating in the area.

Figure 4. Job losses of Cambridge tech firms active in 2004 but no longer present in 2006 by type of firm



In *Figure 5* evidence on micro-firms and on larger firms reveal their differential contribution to high tech employment trends in the area. Larger firms are the 20% of firms in the database (~250 each year out of 2800) with the highest number of employees.

Figure 5 Number of Cambridgeshire tech firms by size of firm between 1988 and 2006

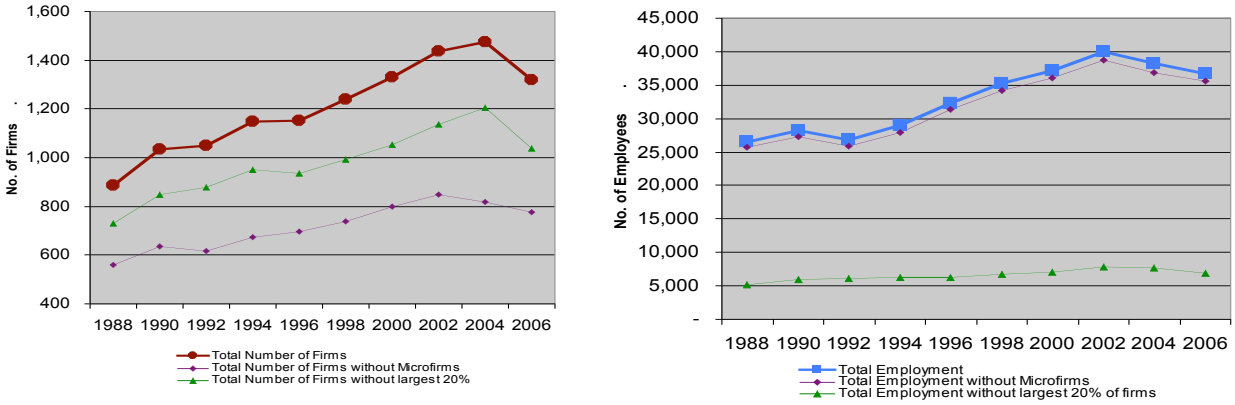
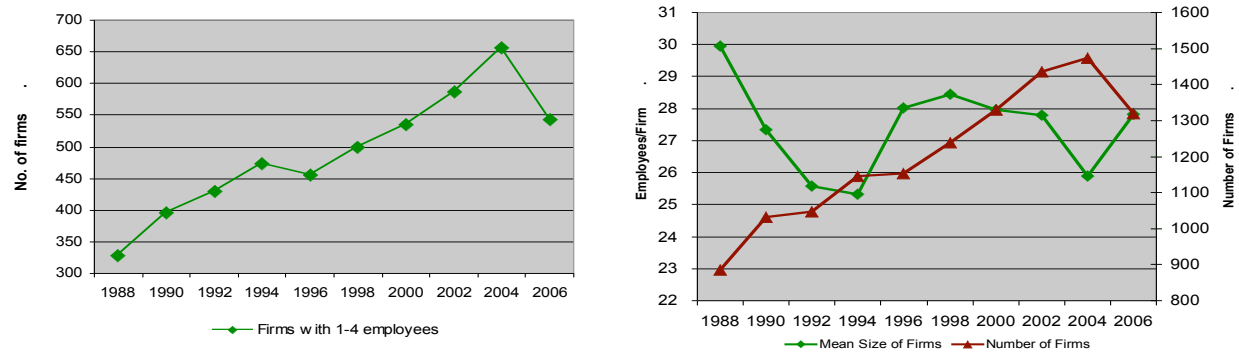


Figure 5 removes the micro-firms from the analysis, revealing their strong contribution to aggregate firm numbers in contrast with employment. The largest 20% of firms were those providing most of the high tech employment in the area, but had a much less visible impact on firm number trends. In Cambridge as elsewhere, larger firms provide the bulk of jobs. For the largest 20% of firms examined, the number of firms mirrors the total employment trend shown in Figure 1.

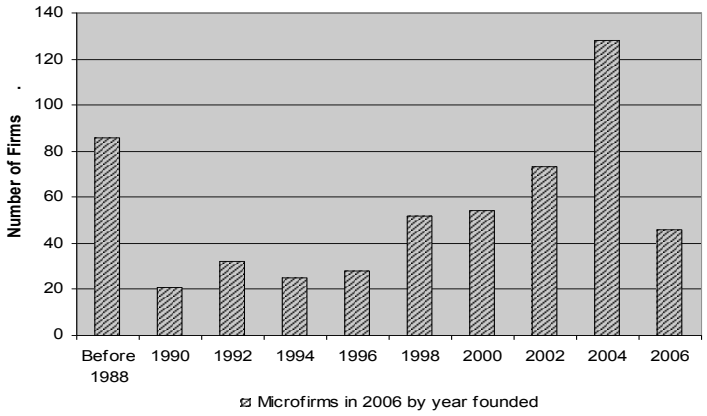
Between 2002 and 2004 (*Figure 5)* large numbers of very small firms were formed in Cambridge as recovery from the tech crash of 2000 occurred and the economy moved into upswing. In contrast, between 2004 and 2006, the number of micro-firms fell by 124. This decrease made up the major part of the total decrease of 155 in the number of technology firms in the database between 2004 and 2006. This effect on firm numbers and the drop in 2006 is also displayed by plotting the mean size of firm (*Figure 6*).

Figure 6 Firms with 1-4 Employees and mean size of firm comparison with total firms in Cambridgeshire



The fall in average size after 2004 and the rise in 2006 indicates that micro-firm start-ups was followed by closures – a pattern is confirmed by *Figure 7* which shows micro-firms by their foundation year.

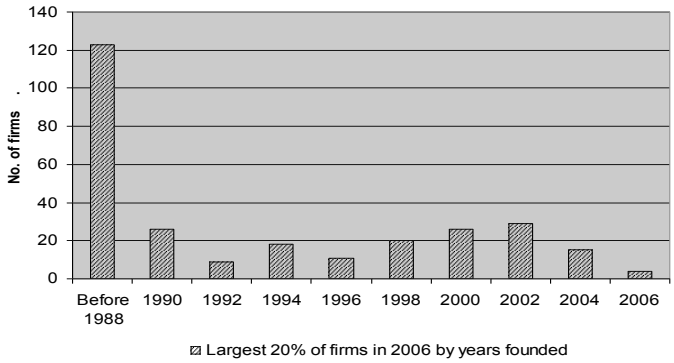
Figure 7 High tech microfirms in Cambridgeshire in 2006



In contrast with micro-firm trends, the larger firms are less likely to be new. Many long-standing firms of a larger than average size, of which there were 123 in total, had been based in Cambridgeshire since 1988 or before *(Figure 8).* As regards start-ups, despite the downturn, it is striking that 74 companies (8% of total founded since 2000) started since 2000 were founded at a sufficiently large size, or had grown enough, to attain the size of the largest 20% of firms.

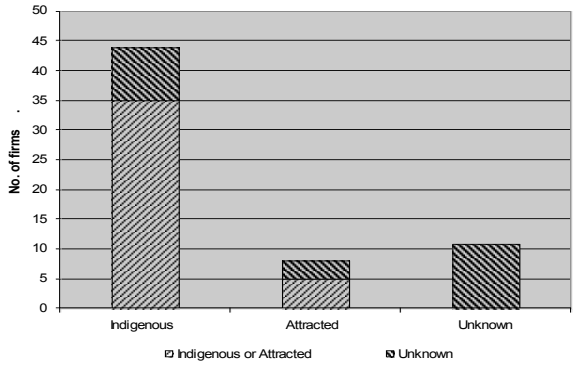
To find out whether larger firms originated as indigenous start-ups or were moved into the area, we used archive sources and telephone interviews to examine the history of the 63 firms that achieved a size of over 100 employees.

Figure 8 High tech larger firms existing in Cambridgeshire in 2006 by year founded



We found that most of the larger established firms had early indigenous roots in Cambridge (*Figure 9*.) rather than being attracted from elsewhere. This points to the value of competencies accumulated locally, persisting through changes of ownership in some cases. We have already seen that branches of implant firms are more likely to close than are indigenous larger firms.

Figure 9 High tech firms with over 100 employees: indigenous vs. attracted establishments.[2]

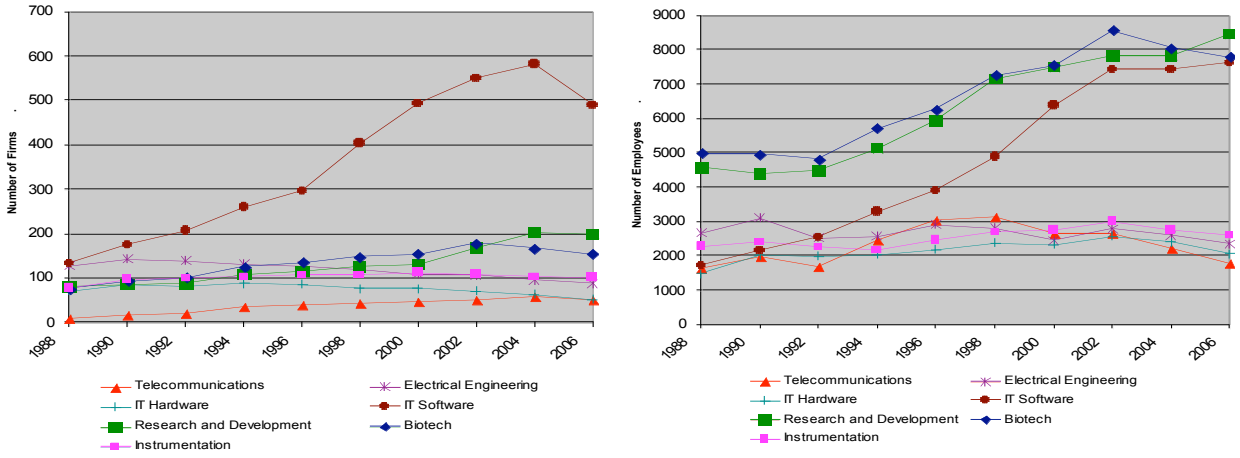


Firms by Sector

Firms are assigned to sectors on the basis of their SIC code. This coding system is unsatisfactory in many respects for tech based firms. For example, it does not identify whether the technologies are still early stage, or recently diffusing (McArthur 1988). However SIC codes do provide some indication of type of activity and allow for some comparison of categories of activity on a longitudinal basis. Figure 10 below shows the breakdown into sectors of activity of tech based firms in Cambridge. Biotechnology, unlike the other sectors, denotes a set of firms that are flagged individually rather than being based on SIC code, and overlaps some other categories, notably R&D.

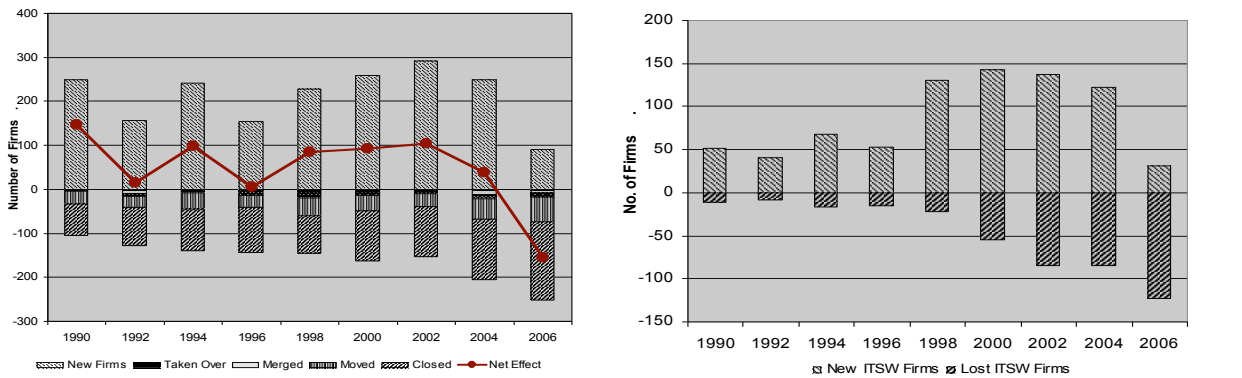
[2] This evidence was obtained by sorting through the database followed by company history research. Companies with unknown or untraceable roots are flagged as unknown; where there is some indication of roots but these are not proven they are added to the appropriate column ('Indigenous' or 'Attracted') as Unknown.

Figure 10 Number of tech-based firms and number of employees by sector in Cambridgeshire (high tech)



Numbers of tech firms in sectors other than software, Biotech and R&D were stable or expanded slowly through the 1990s, with no further growth and in some cases decline after 2000. IT firms, as pioneers and facilitators of high tech activity, have created the largest sector in the Cambridge area, by a significant margin in terms of firm numbers. However IT software firms greatly outnumbered the more capital intensive IT hardware firms which declined over the period (Garnsey and Heffernan 2005). In keeping with the fall in numbers between 2004 and 2006 and rise in average firm size, for IT software, the entry and exit pattern of firms is closely follows the pattern of entry and exit pattern of firms in all sectors (*Figure 11)*.

Figure 11 All firms entries and exits and IT software firm entries and exits



Note: Entries are new firms founded or firms moving into the area. Exits are firms closed, merged or moved.

The boom period of rapid expansion was followed by many fewer IT software start-ups in the period between 2004 and 2006. Aggregate trends for tech firms in the area were shaped by the number of very small IT firms started during the boom period. In principle it is desirable to have a large pool of firms experimenting with related applications of emerging technology. But the very small firms formed during the boom proved unsustainable.

The relative immunity of Cambridge firms to the Internet crash between 2000 and 2002 was partly the result of relatively few high tech Internet firms having been founded in the area.[3] E-business has a high failure rate and required a large pool to generate a few successes. The pattern in Cambridge has been the creation of specialist firms in market niches with a relatively low failure rate, a different dynamic from that in larger population centres with more internet firms. As some e-businesses proved successful (among the many failures) and started to bring in returns to investors, there were few Cambridge firms among them.[4] Nor does Cambridge have a tradition of IT applications in the creative industries. The expansion of this sector elsewhere points to the benefit of bringing together creative and IT skills through polytechnic education, an opportunity not taken up locally where the local polytechnic became an under-funded branch of a multi-campus East-Anglian university (Anglia Ruskin University). Support to Anglia Ruskin University in the creative arts and commerce could stimulate commercial capabilities in creative industries in the area.

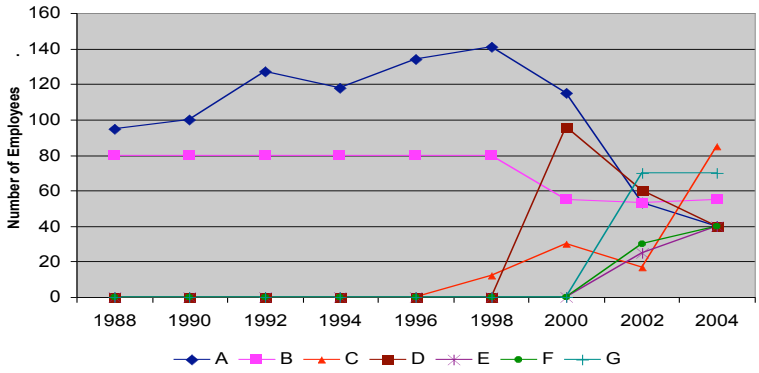
The Biotech[5] and R&D sectors have consistently had the highest number of employees. Biotech firm numbers in early years were inflated by inclusion of research institutes. The sector expanded rapidly in the 1990s but experienced decreasing firm numbers after 2000 and lower employment after 2002 as the financial climate become less favourable to these firms. The erratic growth paths of seven biotech firms that ceased trading in the area are illustrative (Figure 12). Job numbers in science based 'development' companies reflect inputs to an immature resource base, often reliant on venture capital and not yet generating sales or profits.

The research and development sector continued to show an increase in firm and job numbers, as we see below. Not all specialist sectors of activity are captured by SIC codes. Two important activities in the area are ink jet printing and technical design consultancies which provide technical development services to customers (also known as contract research companies). Five of the inkjet printing firms[6] in the area expanded from 297 employees in 1988, to 840 employees in 1998, and up to 1055 employees in 2008. There were intermittent discontinuities in employment growth as firms encountered and overcame

[3] Routine retail e-business that did not use leading edge technologies are not included in the database.
[4] A successful exception is Abcam, which provided antibodies over the internet for the biopharm industry.
[5] Note: Unlike other sector categories, Biotech is not an SIC-based category and there is some overlap with other categories.
[6] These specialist activities were identified on a firm by firm in the database, where employment data was available. Five of the largest ink jet printing firms were used in this sample.

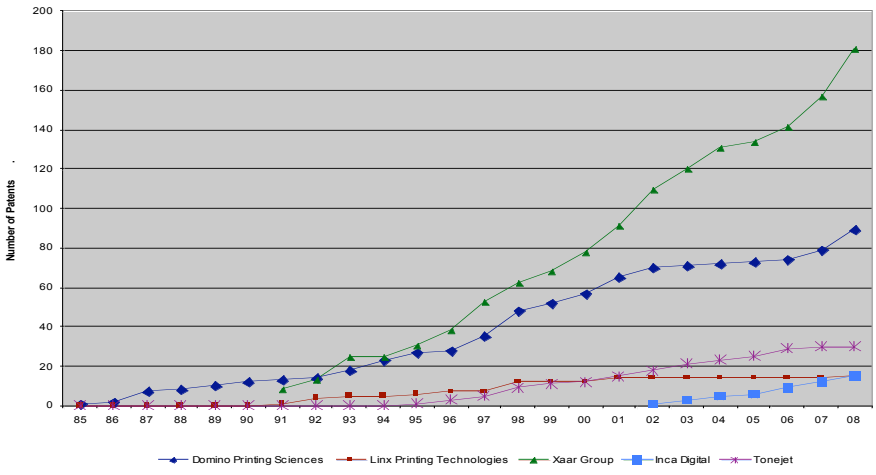
difficulties, but there was no contraction in the steady accumulation of technical competence, as revealed by numbers of patents registered by five of these firms.

Figure 12 Growth paths of larger Biotechs that closed or left before 2006



A - Moved
B - Moved to Headquarters (Part of larger Firm)
C - Closed (Part of larger Firm)
D - Moved
E - Closed
F - Moved
G - Closed

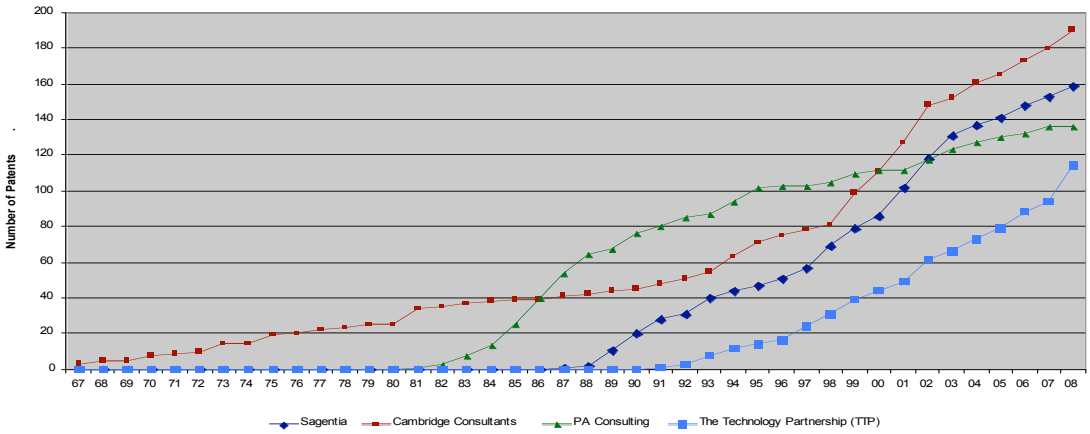
Figure 13 Cumulative patents between 1985 and 2008 for Inkjet Printing Firms



Source: European Patent Office

In the case of technical design consultancies, the four largest have grown from a total of 695 employees in 1988 to 1125 employees in 1998 and to 1375 employees in 2008.

Figure 14 Cumulative patents between 1985 and 2008 for Technical Design Consultancies



Source: European Patent Office

The IP built up by the technical design companies is one reason why they have been a fertile source of spin-outs in the area, with most of the IJP companies originating in Cambridge Consultants Ltd. (Garnsey and Heffernan 2005). Patents are merely a quantifiable indicator of a broader range of business and technical competence, the key advantage of the longstanding Cambridge technology firms.

Ten year trends.

We now turn to the question of decade-long trends in size and sectoral activity of technology firms in the Cambridge area. The database evidence examined here does not reflect directly on the issue of whether congestion has made Cambridge a less attractive place to do business, but this issue requires, as a start, analysis over a longer period than the recent boom and contraction. Our aim here is to examine recent data in longer term perspective; trend lines are drawn for the period of data availability 1988-2006. (*Figure 15, Figure 16)*.[7] The hump of expansion during the boom years 1996-2004 was followed by decline in firm numbers. Whether this reflects a return to the earlier pre-boom trend or further decline will depend on the severity of the recession and whether firms founded in the adverse conditions of recession prove as robust as were the cohorts of the early 1990s.

[7] Some recent changes are missed in the survey and added to the database subsequently.

Figure 15 Boom and stabilisation by sector - Trend line for IT software firm numbers

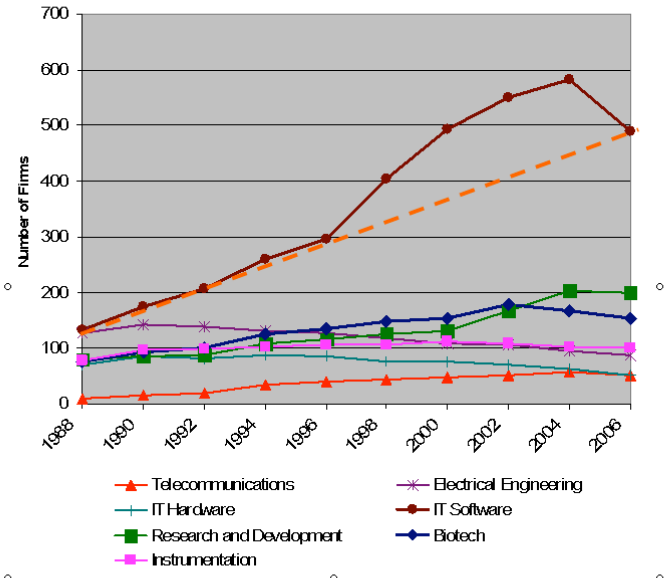
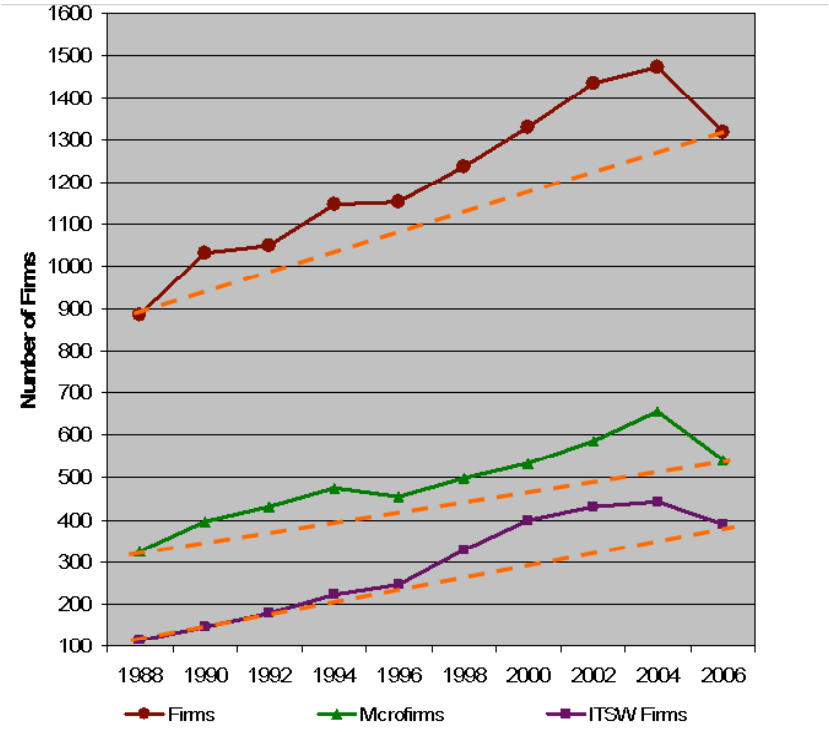


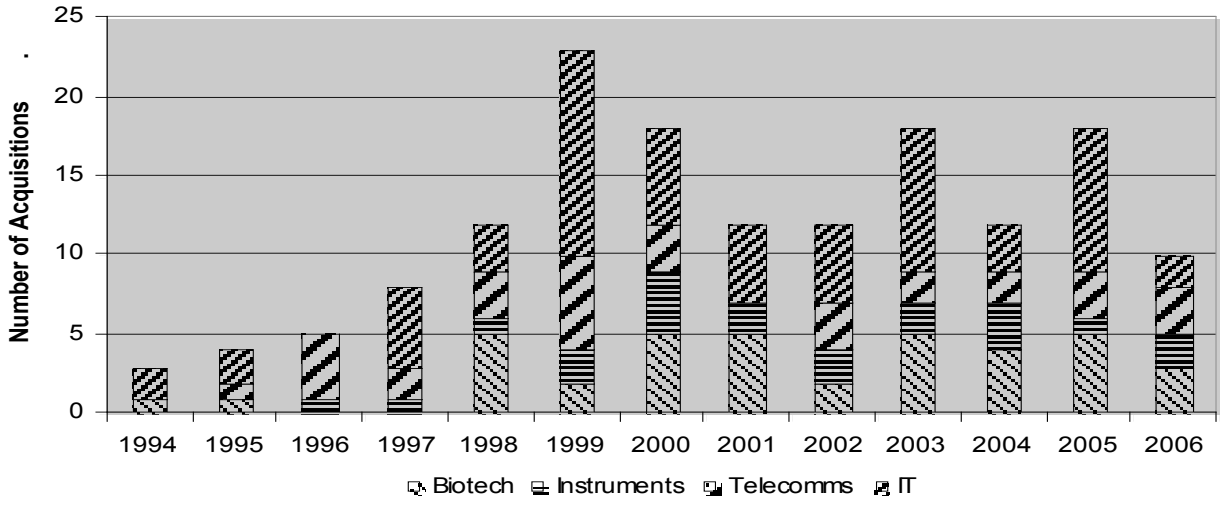
Figure 16 Total number of firms, IT software and microfirms with trend lines 1988-2006



Merger and Acquisition trends

Cambridge technology firms are attractive targets for acquisition by corporations seeking to improve their innovation performance by buying a promising technology and/ or innovative team. *Figure 17* presents the trend in acquisitions in four sectors: telecoms, IT software, instruments and biotechnology. Together these sectors account for the majority of takeovers identifiable in the database since 1988, though further takeovers not flagged in the database have been found from other sources for these sectors.[8] On this evidence, the level of acquisitions increased markedly during the period of the technology boom after 1996. Acquisition rates rose to a peak at the height of the boom in 1999/2000 in telecoms, IT software, and biotechnology but remained stable in the more mature instrumentation sector. The increase in acquisition numbers is likely to reflect the rapid expansion of venture capital investments in the area, since venture capitalists, being intermediaries, are under pressure to exit early to achieve returns for their investors. While there was little VC investment in Cambridge firms before the international technology boom, local tech firms attracted over £250m in VC in 2000 and £300 million in VC in 2001. Investment by VCs in local companies fell to around £150 million in 2003 and to under £50 million in 2006 according to an investment consultancy (Library House 2006; Appendix A). It is not clear whether local acquisitions trends are consequent on local VC investments, annual acquisitions in each sector are small numbers and the period of lag before acquisition is variable.

Figure 17 M&A Transactions by Year, 1994-2006 in biotechnology, IT software, instruments and telecommunications



[8] We are indebted to Vivian Mohr who combed the database firms in the main sectors for takeovers, checking the data against web sources, company histories, backed by direct inquiries, making it possible to present the first cluster-wide data available on acquisitions in the Cambridge area.

To assess the local impact of acquisition, flows of capital into the area and the impact on jobs and firm numbers would, ideally, be examined, but the recipients of capital flows (whether locals or externals) are unknown. Relatively few companies provide performance figures for an acquired unit, but it proved possible to find such data for 47 acquired units. *Table 1* summarises the proportion of units in which expansion occurred pre- and post-acquisition for the firms providing evidence. The majority of acquired units were expanding before takeover, firms acquired being those in the area with best performance and prospects. The proportion of target units continuing to grow after takeover was lower than before takeover in biotech and IT firms. Net contraction occurred after acquisition in instruments and telecomm firms. There were job losses in all four sectors following acquisition of these firms, most noticeably in the telecommunication sector (Table 1).

Table 1 Impact of Acquisition on Employment in 47 Acquired Units in the Cambridge Technology Cluster 1994-2006

Sector	Acquired units for which data are available	Average rate of employ-ment growth before unit acquired	Average rate of employ-ment growth after unit acquired	Net employment change after acquisition (number of jobs)
Biotech	7	74%	7%	**-261**
Instruments	6	1%	-2%	**-305**
Telecom	8	63%	-16%	**-689**
IT	26	51%	10%	**-110**
All	47			**-1365**

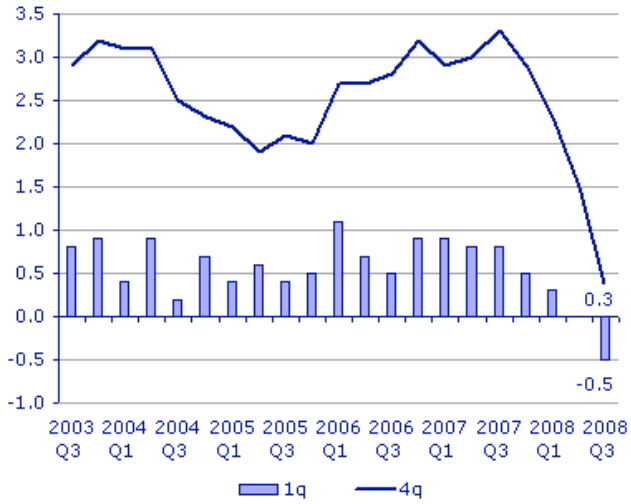
For those firms issuing performance figures for acquired units, there were 1365 fewer jobs after acquisition than there had been when these firms (in biotech, instruments, IT software and telecoms sectors) were independent. We do not know what would have occurred had the firms remained independent, nor whether changes resulted from productivity improvements, strategic reorientation or loss of custom. In the case of biotechnology firms engaged in labour intensive research and development, productivity improvements are an unlikely explanation of contraction. Case study evidence indicates that strategic reorientation by the acquirer is the most usual driver of change in the acquired unit. Acquisitions often result in spin-outs of new companies, but downsizing on this scale was not matched by jobs created in newly formed firms spun out by employees, given the small size of most start-ups. Acquired units become branch firms, subject to subsequent closure and relocation as identified earlier, while spin-outs may subsequently expand.

Economic Volatility and Activity in Emerging Sectors

The fall in national output after 2003 was followed by expansion fuelled by the property boom, ended by the financial crisis. This has been a period of economic volatility in the nation at large *(Figure 18)*. The

pattern of expansion and contraction among Cambridge firms did not mirror these trends because there were other factors at work such as availability of venture capital.

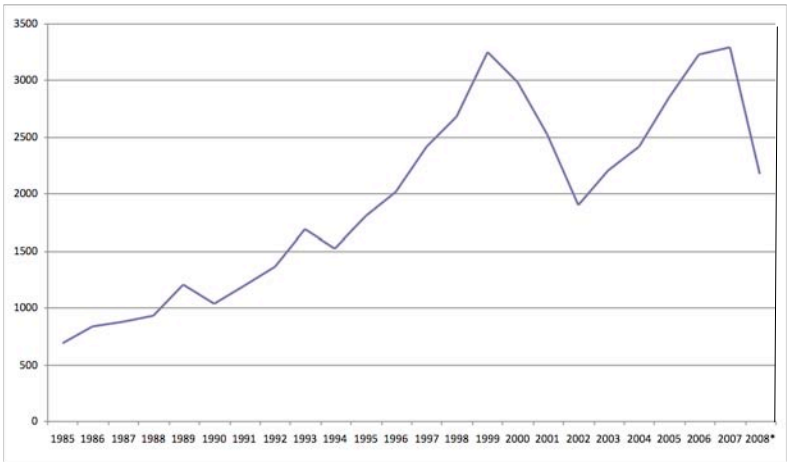
Figure 18 Economic volatility measured by changes in GDP growth in the UK



Source: Office of National Statistics

Figure 19 reflects volatile share price performance in the UK. The bi-modal trend since 1999 reflects the loss of confidence following the technology crash and recovery of confidence related to the property boom. Property boom effects may be reflected in all VAT registered start-ups in Cambridgeshire at large which, as we have seen, remained higher than the rate of entry of technology based Cambridge start-ups through to 2007 (GCP 2007), but this "bounce" was not experienced by the Cambridge technology cluster firms.

Figure 19 Economic volatility in UK measured by FTSE Allshare Index



Source FTSE (chart courtesy of V. Mohr)

Questions that arise include whether the Cambridge tech firms' experience prefigured the credit crunch that later hit the wider economy and whether they will show renewed resilience. We have seen that the Cambridge cluster remained relatively immune to the slump of the early 1990s, with new firms arising to provide jobs lost in the established firms. Cambridge firms may show resilience again, particularly those developing technologies of the future. However the decline of the instrumentation sector of the early 1990s after decades during which this was the main tech sector in the area had very serious consequences. Instrumentation is a major sector in Route 128 and in Silicon Valley. This is a sector in which Cambridge firms should have advantages through close links with leading edge labs, but has become a small local sector engaged in niche activity. The experience of the instruments sector thus shows the danger of lasting impact on key sectors of a recession especially when this is combined with constraints on the carrying capacity of the area resulting from congestion and infrastructure issues.

The decline in numbers and jobs in biotechnology reflect conditions in the capital market as experienced in the pharmaceutical sector as well as internal business development issues. In the environmental goods and services sector there was a period of inflated share prices on the Alternative Investment Market (AiM), followed by a disproportionate slump from 2007. One Cambridge-based firm was left with cash worth over twice what the market capitalisation had fallen to on AiM. Investors first held and then revised unrealistic expectations regarding prospects for short term returns in the clean tech sector.

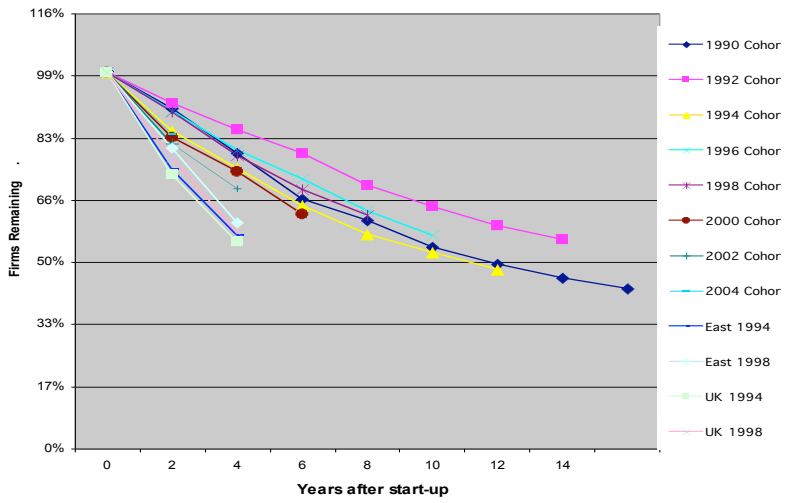
We saw that during recent years venture capital became more plentiful in the Cambridge area. However, at most 10% of tech firms in the Cambridge area were funded by VC (Library House 2006). Young firms continued to need access to bank credit. Former bankers working in the area report that during recent years, the highly centralised UK banks were tightening credit for tech based firms, making it very difficult or impossible for local tech based firms to obtain overdrafts. Credit of the kind that had funded Cambridge firms like Domino Printing Sciences and Acorn Computers in earlier decades had become unobtainable (Herriott et al 2008). This may have reflected banks' preference for loans to the mortgage sector following the deregulation of the banks and building societies, particularly during the period of property boom. Interviews with former bankers indicate that the key shortage was of bankers knowledgeable about technology firms. According to David Gill who was head of the Innovation Unit at HSBC "The resource being constrained was <u>not</u> money primarily but people (dedicated tech specialists)." Specialised technology teams were closed down in banks after the tech boom. "By the time the property market started to overheat from 2004, there was no incentive (for banks) to build long-term firms." The topic requires further investigation.

Cambridge has benefited from the continued flow of funds and talent through the university, which is more immune to recession than most organisations (Shahid and Kaora, 2007). There are over 300 firms

directly originating from the university in the area (Garnsey and Heffernan 2002). These are particularly vulnerable in their first years and so would be very sensitive to financial conditions.

We saw that the expansion of the technology cluster depends on entries exceeding exits and on the survival and growth of cluster firms. We have seen that the distribution of firms is not less favourable in terms of size than that found nationally, and that since 2000 over 70 firms grew to reach the largest size category. It is also of interest to compare survival rates of firms started in the Cambridge area in succeeding periods (*Figure 20).* The survival rates for Cambridge high tech firms were unusually high, and exceeded rates for all East Anglia firms[9] and UK firms (Garnsey and Heffernan 2005). Cambridge high tech firms performed well collectively in comparison to county data and national data. The lower rates for firms founded in the boom years are identifiable in Figure 19. Only firms with better prospects may have been founded in the recession of the early 1990s and these benefited from the economic expansion later in the decade. This historical precedent shows that the long term effects of the fall in start-up rates after 2004 could be remedied if survival rates improved.

Figure 20 Survival Rates by Cohort of Cambridge High Tech Firms



New Activity

Whether trends will recover in the Cambridge technology cluster will depend heavily on the success of new activity, such as occurred in the early 1990s when job losses in older companies were replaced by new jobs in emerging sectors. Newcomer firms spinning out from the university or starting up in the local enterprise centres may prefigure future trends as regards emerging tech-based activities. The websites of Cambridge Enterprise, St. Johns Innovation Centre and the Science Park were examined to see how many firms engaged in new types of activity have entered their directories (*Table 2*.) This is

[9] http://stats.berr.gov.uk/ed/survival/

only a partial audit of firms in new sectors, but provides evidence of a shift into new activity during a period when the number of start-ups was contracting.

Table 2 Emerging sector firms associated with Cambridge Enterprise, St. Johns Innovation Centre, Cambridge Science Park

Total Number of Emerging sector firms from Cambridge Enterprise, St. Johns Innovation Centre and the Cambridge Science Park	**35**
	Number of Firms
Display Technology	6
Energy, Environment, Sustainability	7
New/Intelligent Materials	8
Consulting for Emerging Sectors	1
Web/Media	13

http://www.enterprise.cam.ac.uk/equityportfolio.php
http://www.stjohns.co.uk/welcome/tenants/tenants.html
http://www.cambridgesciencepark.co.uk/companies/110/full-list

The seven new firms with environmental technologies are accompanied by firms in other sectors (e.g. materials, R&D) with potential applications for the natural environment. Firms engaged in R&D are harbingers of new activity and these were found to be increasing in number, by over a hundred in five years.

Table 3 R&D firms founded between 2000 and 2006

Total Number of R&D firms founded between 2000 and 2006	**101**
Breakdown	**Number of Firms**
Medical Research and Development	23
Bioinformatics	8
Information and Communication Research and Development	15
Energy and Environment	14
Display	7
Materials	6
Printing	3
Other (Manufacturing, Leisure, safety and security, media, consultants etc.	25

Reflections and further work

A database of all high tech firms in the Cambridge area has been used here to trace the growth of firms in diverse sectors. We have shown that a local firm's longevity is important to the accumulation of local competencies. In previous papers we have shown that many of the high tech firms in the area originated in the university, while others were attracted to the area or were encouraged by the success of others to start in Cambridge on an independent basis (Garnsey and Heffernan 2005). There has been flow of talented and knowledgeable people who have found

ways to apply knowledge to new areas of activity, a key stimulus to the Cambridge technology cluster. Competence accumulates through successive spin-outs of knowledge-based firms, as well as within specific firms. To trace the impact of firms originating in the university it is not enough to look at the first generation of firms. Spin-outs from previous spin-out firms create new clusters of activity over time. We have traced the development of new clusters, the Cambridge ink jet printing cluster and the ensuing display technology cluster, which originated from one university spin out firm, CCL. Competence can be transferred from one application to another, resulting in the emergence of new activity. Ink jet printing has proved to be more than a printing technology. It is now seen to be a deposition technology that can transform the way in which intelligent materials are created. One promising example is the display technology cluster, with high-growth start-ups like Cambridge Display Technology and Plastic Logic. New applications of the principles on which their technologies depend can give rise to environmental innovations.

Technology based enterprises commercialise knowledge with transformative potential that reveals itself over time. Today many Cambridge firms are developing innovations with actual or potential applications to environmental products and services. New companies need customers for their innovations. Government procurement of innovative products and services could demonstrate their value and stimulate private sector demand. In the Netherlands, all products procured by government will have to achieve high standards of sustainability by 2012, a way of stimulating demand for environmental innovation.

Demand for innovative products, capital for innovation and skilled and enterprising people are the ingredients for sustaining an innovative cluster. Continued support for scientific and engineering research in grants for doctoral and post-doctoral research are critical. Since quality of life has been a key attraction for the latter, neglected infrastructure and unrelieved congestion must be addressed. Local problem-solving by those most closely affected is hampered by centralisation of decision-making and of budgets and by the lack of integrated city development (Parkinson et al. 2006).

As regards the availability of capital, in real value-creation there is delay and new firms lack retained earnings to tide them over. Value-creating companies must be able to access credit and external finance. Returns captured by technology investors from specific companies tend to be highly cyclical, setting off further cycles of funding availability. We have seen that Cambridge

technology based firms are highly sensitive to cyclical trends in the economy. Though resilient over a quarter of a century, they have been showing signs of contraction since the technology downturn. While credit was available, they were subject to pressure from the financial sector to achieve value-capture more rapidly than was feasible. Unless these firms have the funds to create new value for users, financial value-capture cannot be sustained.

References

Atella, V., Centoni, M. And Cubadda, G. (2008) Technology shocks, structural breaks and the effects on the business cycle. *Economic Letters*, 100 (3), 392-395

Audretsch, D.B. and Acs, Z.J. (1994) New-Firm Startups, Technology and Macroeconomic Fluctations. Small Business Economics, 6 (6), 439-449

Baines, D., N. Crafts and T. Leunig (2001): "Railways and the Electronic Age", London School of Economics Working Paper www.fathom.com

Best, M. H. (2000) Silicon Valley and the resurgence of Route 128: systems integration and regional innovation, in Dunning, J. H. (ed.), *Regions, Globalization and the Knowledge-Based Economy* (Oxford: Oxford University Press) pp. 459- 484.

Collard, F. and Dellas, H. (2007), Technology Shocks and Employment. *The Economic Journal,* 117, 1436-1459

Garnsey, E. and Heffernan P. (2005) High Tech Clustering through Spin-out and Attraction; the Cambridge Case, *Regional Studies* 39(8): 1127-1144.

Greater Cambridge Partnership Annual Profile (2007), Greater Cambridge Partnership
Herriot W., et al, 2007, Bank Support for Early Stage Technology Businesses, unpublished report, St John's Innovation Centre

Library House (2006) *The Cambridge University Economic Impact Study*. Library House Ltd: Cambridge.

McArthur, R. (1990) *Replacing the concept of high technology: towards a diffusion basedapproach.* Environment and Planning A, vol. 22, issue 6, pages 811-828

Minshall (2008), Cambridge Technopole Report, St John's Innovation Centre, Cambridge

Mowery, D.C. and Rosenberg, N. (1998) *Paths of Innovation. Technological Change in 20th-Century America*. Cambridge University Press

OECD. 2000. *A New Economy*? Paris: OECD.

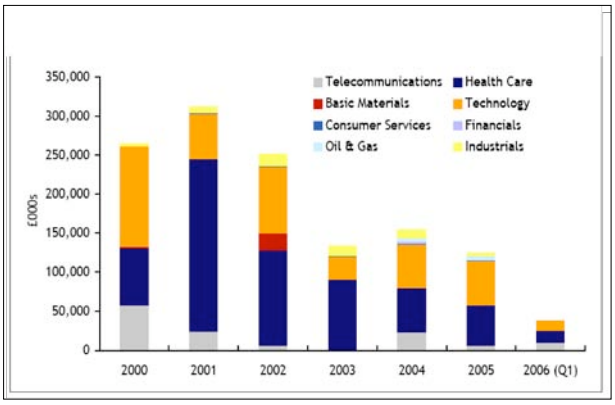
Owen, G. (2004) Where are the big gorillas? High technology entrepreneurship in the UK and the role of public policy. Discussion paper Interdisciplinary Institute of Management, London School of Economics

Parkinson M. et al., 2006 *State of the English Cities*, volumes 1 and 2, HMSO London

Penrose, E. (1959) *The Theory of the Growth of the Firm.* Oxford Press. (not found in text)

University of Cambridge Research Services, Cambridge Enterprise (2007) http://www.rsd.cam.ac.uk/

Appendix A Venture Capital Funds attracted by Cambridge Companies, 2000-2006



Source Library House, 2006, *The Supercluster Question, The Cambridge Cluster Report 2006,* Library House Cambridge Reproduced with permission.

Appendix B Cambridgeshire High-tech Database

The records on the Cambridgeshire County Council on the population of high tech firms in the county were used to create a database of high-tech firms, derived from biennial surveys of employment in local firms. This is the basis for the evidence analysed here tracking employment data by firm over a twenty year period. The firms' self-description of activities is used to identify knowledge intensive ("high tech") activity and to assign this to standard industrial categories. The Cambridge County Council Research Group has been collecting employment data for all the high-tech firms in Cambridgeshire and Peterborough since 1985, for the purpose of monitoring the region's employment development and trends. The dataset contained information on around 3000 high-tech firms, where high-tech refers to firms with high-tech inputs (1) R&D budget (2) above average proportion of science and technology employees (3) firms that by their activity description use emerging and newly-diffusing technology. These data were refined to remove university departments, retailing and other units that were not directly relevant to the analysis of high-tech business.

The county employers'database includes Peterborough companies but as these are not part of the high tech locality around Cambridge they are excluded in the aggregate figures reported here. It was found that inclusion and exclusion of Peterborough companies made little difference to aggregate trends since there are relatively few high tech companies in the Peterborough area. The database we have been using includes research institutes with sizeable private industry funding. When the analysis was carried out again excluding such institutes, it was found that the major trends were not affected. The number of biotech employees is higher in the 1980s when research institutes are included. The biotech firms are flagged as such in the database; sectoral distribution based on SIC does not identify biotech separately.

Acknowledgements

Alex Drofiak's work was funded by the EPSRC Innovation and Productivity Grand Challenge EP/C534239/1 We are grateful to Rebecca Roebuck of the Cambridgeshire County Council Research Group for her help and to David Gill, Walter Herriot, Tim Minshall, David Connell, Peter Hewkin and Erik Stam for comments on previous drafts.